UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME	:	GEOTECHNICS II
COURSE CODE	:	BFC 21702
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JANUARY / FEBRUARY 2024
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTIONS	:	1. PART A : ANSWER ALL QUESTIONS PART B : ANSWER ANY TWO (2) QUESTIONS ONLY 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☒ Open book ☐ Closed book 3. DESIGN SHOULD BE BASED ON BS EN1990:2002A+A1:2005, BS EN1991-1-1:2002, BS EN1992-1-1:2004, MS 1553:2002.

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

PART A (ANSWER ALL QUESTIONS)

Q1 (a) Discuss the concept of the effective stress and its significant in geotechnical engineering.

(5 marks)

(b) **Figure Q1.1** shows soil profile of dry sand and clay.

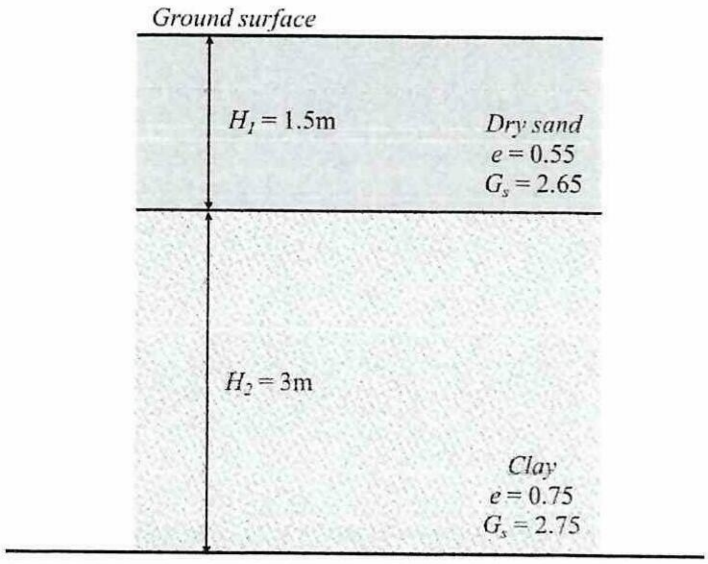

Figure Q1.1 The soil profile of dry sand and clay layer

Determine the effective stress of the soil if:

(i) The groundwater table is very far from the ground surface.

(5 marks)

(ii) The groundwater table is located at the ground surface.

(5 marks)

(iii) The groundwater table is located at 0.5 meter from the ground surface.

(5 marks)

(c) **Figure Q1.2** shows a layer of soil in a tank with upward seepage. Given the $H_1 = 1.0$ m, $H_2 = 2.0$ m, $z = 0.5$ m and $h = 1.2$ m.

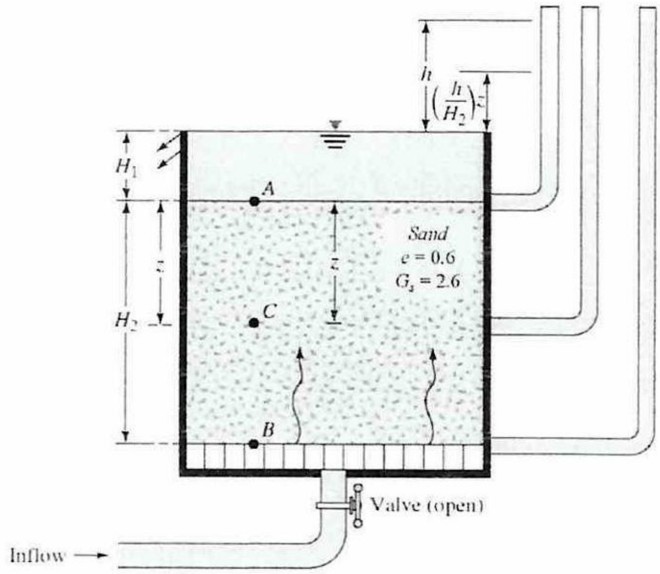

Figure Q1.2 Layer of soil in tank with upward seepage

Determine the effective stress at Point B and C.

(5 marks)

Q2 (a) A soil element in the field has various complicated stress paths during the lifetime of a geotechnical structure. The behaviour of this soil can be predicted under more realistic field conditions. Briefly discuss simulation field conditions in the laboratory using shear strength test.

(4 marks)

(b) A consolidated-drained triaxial test was conducted on a normally consolidated clay. Compute the angle, θ that the failure plane makes with the major principal stress, if the laboratory test results is given as follows;

- $\sigma_3 = 300$ kN/m^2
- $(\Delta\sigma_d)_f = 150$ kN/m^2

(4 marks)

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(c) **Table Q2.1** shows the result of triaxial test of three soil samples under consolidated undrained conditions.

Table Q2.1 Data of triaxial test

Sample name	Confining pressure (kN/m^2)	Porewater pressure at failure (kN/m^2)
Sample 1	100	51
Sample 2	150	77
Sample 3	300	159

If the deviator stress is applied on sample 1 = 55 kN/m^2, sample 2 = 75 kN/m^2 and sample 3 = 140 kN/m^2;

(i) Plot the complete Mohr-circle in term of total stress and effective stress on the same graph.

(9 marks)

(ii) Determine the cohesion and friction angle for total stress and effective stress.

(4 marks)

(iii) Briefly discuss on the result obtained in **Q2(c)(ii)**.

(4 marks)

PART B (ANSWER ANY TWO QUESTIONS)

Q3 (a) Soil particle size distribution can be determined by sieving method, sedimentation or hydrometer and particle counting methods. Briefly explain the main differences between sieving method and hydrometer method.

(2 marks)

(b) **Table Q3.1** shows the result of particle size distribution of soil which obtained from Kluang. It was observed that from the Atterberg limit test, the soil liquid limit and plastic limit are 22 and 16 respectively.

Table Q3.1 Data of particles distribtion anlysis

Analysis	Sieve No.	Size, mm	% Finer
Sieve	40	0.425	100.0
	80	0.180	96.0
	170	0.090	85.0
	200	0.075	80.0
Hydrometer	N/A	0.0400	59.0
		0.0200	39.0
		0.0100	26.0
		0.0050	15.0
		0.0015	8.0

From the given results and information from **Figure APPENDIX A.1** to **Figure APPENDIX A.3**;

(i) Plot the particle size distribution (gradation) curve.

(6 marks)

(ii) Determine the textural composition of the soil (the amount of gravel, sand, etc.)

(3 marks)

(iii) Determine the uniformity coefficient and the coefficient of curvature.

(4 marks)

(iv) Classify the soil based on USCS system.

(4 marks)

(c) Dry sand was poured to fill the container which has the volume = 3.0×10^{-3} m^3 and weight 10 N. The container and the sand weigh is 55.5N. Assume specific gravity of soil is 2.68. Determine the void ratio and the porosity of soil.

(6 marks)

Q4 (a) Differentiate between compaction and consolidation process.

(4 marks)

(b) The results of a standard Proctor test are given in the **Table Q4.1**. The volume of Proctor mould is 943.3 cm^3.

Table Q4.1 Results of a standard Proctor test

Trial No.	Weight of moist soil, kg	Moisture content, %
1	1.68	9.9
2	1.71	10.6
3	1.77	12.1
4	1.83	13.8
5	1.86	15.1
6	1.88	17.4
7	1.87	19.4
8	1.85	21.2

By using $G_s = 2.68$;

(i) Plot a graph to determine the maximum dry density of compaction and the optimum moisture content.

(8 marks)

(ii) Plot the zero air voids line.

(4 marks)

(iii) Determine void ratio and degree of saturation at the optimum moisture content.

(4 marks)

(iv) **Table Q4.2** portray the results of sand cone tests (quality control test) at five different locations after field compaction.

Table Q4.2 Results of a field sand cone test

Location	Density, kg/m^3	Moisture content, %
1	1690	13.5
2	1680	16.5
3	1650	17
4	1685	18.5
5	1850	19

The required specifications are:

- dry density must be at least 95% of maximum dry density.
- moisture content, w should be within ± 2% of optimum moisture content.

Plot the specification and sand cone test results on your **Q4(b)(i)** graph and give comments about the quality of the test.

(5 marks)

Q5 (a) Hydraulic gradient is representing the energy or driving force for liquid flow (water) through the void spaces of soil and can be considered as laminar. Based on the statements, sketch a diagram and briefly describe the relationship between hydraulic gradient and velocity.

(5 marks)

(b) A soil sample 12 cm in diameter is placed in an inclined tube 1 m long as shown in **Figure Q5.1**.

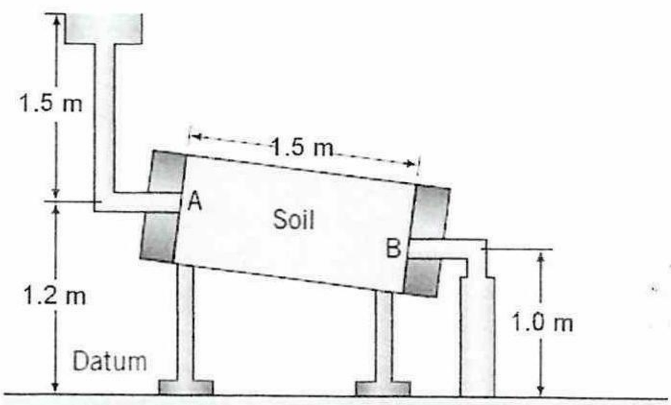

Figure Q5.1 Flow of water through soil tube.

A constant supply of water is allowed to flow into one end of the soil at A, and the outflow at B is collected by a beaker. The average amount of water collected is 1.2 cm^3 for every 12 seconds. Given the void ratio of the soil is 0.6. Determine the hydraulic gradient, flow rate, average velocity, seepage velocity and hydraulic conductivity.

(10 marks)

(c) A sample of sand, 7.5 cm in diameter and 20 cm long, was prepared at a porosity of 65% in a constant-head apparatus. The total head was kept constant at 40 cm and the amount of water collected in 10 seconds was 100 cm^3. The test temperature was 20°C. Calculate the hydraulic conductivity and the seepage velocity.

(5 marks)

(d) The data from a falling-head test on a silty clay are:

- Cross-sectional area of soil = 80 cm^2
- Length of soil = 10 cm
- Initial head = 90 cm
- Final head = 84 cm
- Duration of test = 15 minutes
- Diameter of tube = 6 mm
- Temperature = 22°C

Determine the hydraulic conductivity.

(5 marks)

- END OF QUESTIONS -

APPENDIX A: Figures, Charts and Tables

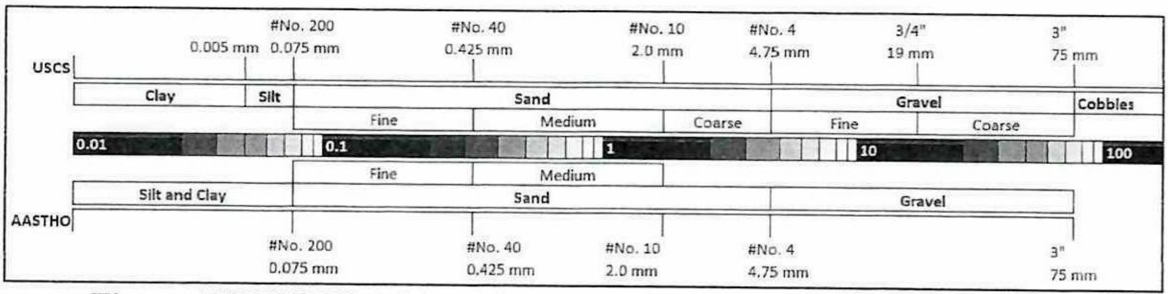

Figure APPENDIX A.1 Particle size classification for USCS and AASHTO

Group symbol		Group name
GW	<15% sand	Well-graded gravel
	≥15% sand	Well-graded gravel with sand
GP	<15% sand	Poorly graded gravel
	≥15% sand	Poorly graded gravel with sand
GW-GM	<15% sand	Well-graded gravel with silt
	≥15% sand	Well-graded gravel with silt and sand
GW-GC	<15% sand	Well-graded gravel with clay (or silty clay)
	≥15% sand	Well-graded gravel with clay and sand (or silty clay and sand)
GP-GM	<15% sand	Poorly graded gravel with silt
	≥15% sand	Poorly graded gravel with silt and sand
GP-GC	<15% sand	Poorly graded gravel with clay (or silty clay)
	≥15% sand	Poorly graded gravel with clay and sand (or silty clay and sand)
GM	<15% sand	Silty gravel
	≥15% sand	Silty gravel with sand
GC	<15% sand	Clayey gravel
	≥15% sand	Clayey gravel with sand
GC-GM	<15% sand	Silty clayey gravel
	≥15% sand	Silty clayey gravel with sand
SW	<15% gravel	Well-graded sand
	≥15% gravel	Well-graded sand with gravel
SP	<15% gravel	Poorly graded sand
	≥15% gravel	Poorly graded sand with gravel
SW-SM	<15% gravel	Well-graded sand with silt
	≥15% gravel	Well-graded sand with silt and gravel
SW-SC	<15% gravel	Well-graded sand with clay (or silty clay)
	≥15% gravel	Well-graded sand with clay and gravel (or silty clay and gravel)
SP-SM	<15% gravel	Poorly graded sand with silt
	≥15% gravel	Poorly graded sand with silt and gravel
SP-SC	<15% gravel	Poorly graded sand with clay (or silty clay)
	≥15% gravel	Poorly graded sand with clay and gravel (or silty clay and gravel)
SM	<15% gravel	Silty sand
	≥15% gravel	Silty sand with gravel
SC	<15% gravel	Clayey sand
	≥15% gravel	Clayey sand with gravel
SC-SM	<15% gravel	Silty clayey sand
	≥15% gravel	Silty clayey sand with gravel

Figure APPENDIX A.2 Flowchart group names for gravelly and sandy soils

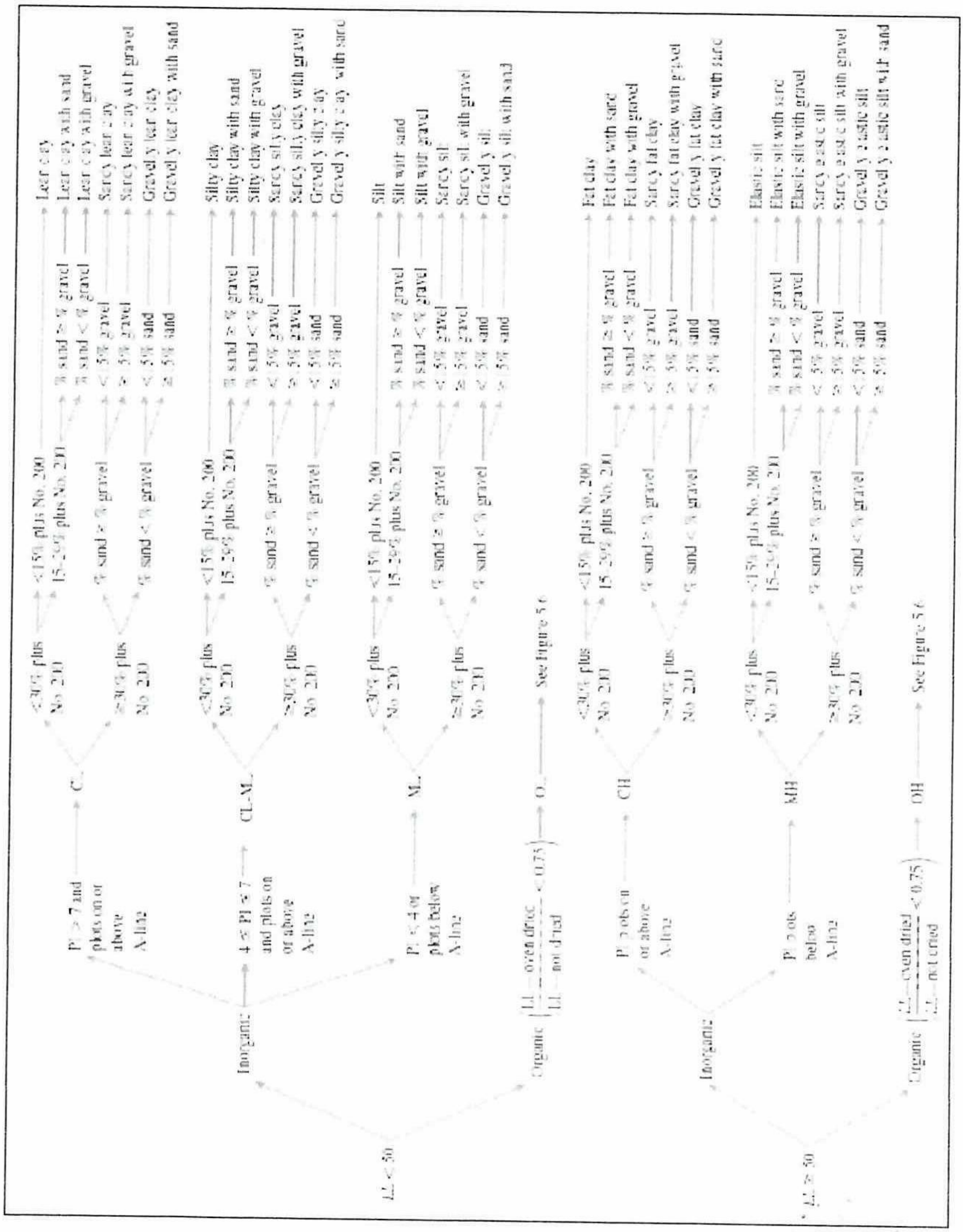

Figure APPENDIX A.3 Flowchart group names for inorganic silty and clayey soils

APPENDIX B: Formulas

The following information may be useful. The symbols have their usual meaning.

$$\gamma = \frac{W}{V_m} \qquad \rho_d = \frac{G_s \rho_w}{1 + \frac{wG_s}{S_r}} \qquad \rho_d = \frac{\rho}{1 + \frac{w}{100}} \qquad Se = wG_s$$

$$\gamma_d = \frac{\gamma}{1 + \frac{w(\%)}{100}} \qquad \gamma_d = \frac{G_s \gamma_w}{1 + \frac{G_s w}{S}} \qquad \gamma_{sat} = \frac{(G_s + e)\gamma_w}{1+e} \qquad n = \frac{e}{1+e}$$

$$\tau' = c + \sigma_n' \tan\phi' \qquad k = \frac{q}{Ai} \qquad k_{eq} = \sqrt{k_z k_x} \qquad \theta = 45^\circ + \frac{\phi}{2}$$

$$E = \frac{\text{Number of Blow/Layer} \times \text{number of Layer} \times \text{Weight of Hammer} \times \text{Hight of Drop}}{\text{Mold Volume}}$$

$$\sigma_3 = \sigma_1 \tan^2\left(45^\circ + \frac{\phi}{2}\right) + 2c\tan\left(45^\circ + \frac{\phi}{2}\right) \qquad \sigma_3 = \sigma_1 \tan^2\left(45^\circ - \frac{\phi}{2}\right) - 2c\tan\left(45^\circ - \frac{\phi}{2}\right)$$

$$\sigma_n = \frac{\sigma_1 + \sigma_3}{2} + \frac{\sigma_1 - \sigma_3}{2}\cos 2\theta \qquad \tau_f = \frac{\sigma_1 - \sigma_3}{2}\sin 2\theta \qquad q_i = Ak_{eq}i$$

$$k = 2.303\frac{aL}{At}\log_{10}\frac{h_1}{h_2} \qquad k = \frac{2.303q\log_{10}\left(\frac{r_1}{r_2}\right)}{\pi\left(h_1^2 - h_2^2\right)} \qquad k = \frac{q\log_{10}\left(\frac{r_1}{r_2}\right)}{2.727H\left(h_1 - h_2\right)} \qquad k = \frac{QL}{Aht}$$

$$i = \frac{\Delta h}{L} \qquad k = \frac{v}{i} \qquad q = \frac{Q}{t} \qquad v = \frac{q}{A}$$

$$v_s = \frac{v}{n} \qquad k = \frac{aL\ln\left(\frac{h_1}{h_2}\right)}{A\left(t_2 - t_1\right)} \qquad R_T = 2.42 - 0.475\ln(T) \qquad k_{20^\circ} = kR_T$$

$$\sigma_3 = \sigma_1 - \Delta\sigma \qquad \sigma_1 = \sigma'_1 - \Delta u_f \qquad v_s = \frac{ki}{n} \qquad \sigma_3 = \sigma'_3 - \Delta u_f$$

$$D_{60} = D_{10}C_u \qquad D_{30} = \sqrt{D_{10}D_{60}C_c}$$

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